

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Timber Branch		Location: BEHI #1	
Station: 32 Ft		Observers: Biggs/Hepp	
Date: 3/28/18	Stream Type: G3	Valley Type: VI	

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	6.00 (A)	Bankfull Height (ft) =	0.97 (B)	(A) / (B) =	6.19 (C)
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Root Depth / Study Bank Height (E)

Root Depth (ft) =	1.00 (D)	Study Bank Height (ft) =	6.00 (A)	(D) / (A) =	0.17 (E)
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Weighted Root Density (G)

Root Density as % =	15.00 (F)	(F) × (E) =	2.50 (G)
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Bank Angle (H)

Bank Angle as Degrees =	85 (H)
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Surface Protection (I)

Surface Protection as % =	10% (I)
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BEHI Score (Fig. 3-7)

10.0

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI) Boulders (Overall Low BEHI) Cobble (Subtract 10 points if uniform medium to large cobble) Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand) Sand (Add 10 points) Silt/Clay (no adjustment)
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Bank Material Adjustment

5

Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

5

Very Low	Low	Moderate	High	Very High	Extreme	
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

Adjective Rating and Total Score

Extreme 52.2

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)									
Stream: Timber Branch					Location: BEHI #1				
Station: 32 ft			Stream Type: G3			Valley Type: VI			
Observers: Biggs/Hepp					Date: 3/28/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1)	Channel pattern, transverse bar or split channel/central bar creating NBS					Level I	Reconnaissance		
(2)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})					Level II	General prediction		
(3)	Ratio of pool slope to average water surface slope (S_p / S)					Level II	General prediction		
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})					Level II	General prediction		
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})					Level III	Detailed prediction		
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})					Level III	Detailed prediction		
(7)	Velocity profiles / Isovels / Velocity gradient					Level IV	Validation		
Level I	(1)	Transverse and/or central bars-short and/or discontinuous.....NBS = High / Very High Extensive deposition (continuous, cross-channel).....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.....NBS = Extreme							
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	Ratio R_c / W_{bkf}	Near-Bank Stress (NBS)	<div style="border: 1px solid black; padding: 5px; text-align: center;"> Dominant Near-Bank Stress High / Very High </div>			
	(3)	Pool Slope S_p	Average Slope S	Ratio S_p / S	Near-Bank Stress (NBS)				
	(4)	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p / S_{rif}	Near-Bank Stress (NBS)				
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	Ratio d_{nb} / d_{bkf}	Near-Bank Stress (NBS)				
	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft ²)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft ²)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
Level IV	(7)	Velocity Gradient (ft / sec / ft)		Near-Bank Stress (NBS)					
Converting Values to a Near-Bank Stress (NBS) Rating									
Near-Bank Stress (NBS) ratings	Method number								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50		
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00		
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60		
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00		
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40		
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
Overall Near-Bank Stress (NBS) rating						Very High			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Timber Branch		Location: BEHI #3	
Station: 166 Ft		Observers: Biggs/Hepp	
Date: 3/28/18	Stream Type: G3	Valley Type: VI	

Study Bank Height / Bankfull Height (C)					BEHI Score (Fig. 3-7)
Study Bank Height (ft) =	8.00 (A)	Bankfull Height (ft) =	0.97 (B)	$(A) / (B) =$	8.25 (C)
					10.0

Root Depth / Study Bank Height (E)					
Root Depth (ft) =	1.00 (D)	Study Bank Height (ft) =	8.00 (A)	$(D) / (A) =$	
				0.13 (E)	
					8.0

Weighted Root Density (G)					
Root Density as % =	5.00 (F)	$(F) \times (E) =$			
		0.63 (G)			
					9.5

Bank Angle (H)		
Bank Angle as Degrees =	75 (H)	
		5.3

Surface Protection (I)		
Surface Protection as % =	10% (I)	
		9.0

Bank Material Adjustment: Bedrock (Overall Very Low BEHI) Boulders (Overall Low BEHI) Cobble (Subtract 10 points if uniform medium to large cobble) Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand) Sand (Add 10 points) Silt/Clay (no adjustment)	Bank Material Adjustment <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">5</div> Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">5</div>
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Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: auto; margin-right: auto;">51.8</div>
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)									
Stream: Timber Branch					Location: BEHI #3				
Station: 166 ft			Stream Type: G3			Valley Type: VI			
Observers: Biggs/Hepp					Date: 3/28/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1)	Channel pattern, transverse bar or split channel/central bar creating NBS					Level I	Reconnaissance		
(2)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})					Level II	General prediction		
(3)	Ratio of pool slope to average water surface slope (S_p / S)					Level II	General prediction		
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})					Level II	General prediction		
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})					Level III	Detailed prediction		
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})					Level III	Detailed prediction		
(7)	Velocity profiles / Isovels / Velocity gradient					Level IV	Validation		
Level I	(1)	Transverse and/or central bars-short and/or discontinuous.....NBS = High / Very High Extensive deposition (continuous, cross-channel).....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.....NBS = Extreme							
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	Ratio R_c / W_{bkf}	Near-Bank Stress (NBS)	<div style="border: 1px solid black; padding: 10px; text-align: center;"> Dominant Near-Bank Stress High / Very High </div>			
	(3)	Pool Slope S_p	Average Slope S	Ratio S_p / S	Near-Bank Stress (NBS)				
	(4)	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p / S_{rif}	Near-Bank Stress (NBS)				
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	Ratio d_{nb} / d_{bkf}	Near-Bank Stress (NBS)				
	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft ²)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft ²)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
Level IV	(7)	Velocity Gradient (ft / sec / ft)		Near-Bank Stress (NBS)					
Converting Values to a Near-Bank Stress (NBS) Rating									
Near-Bank Stress (NBS) ratings	Method number								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50		
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00		
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60		
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00		
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40		
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
Overall Near-Bank Stress (NBS) rating						High			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Timber Branch		Location: BEHI #4	
Station: 48 Ft		Observers: Biggs/Hepp	
Date: 3/28/18	Stream Type: G3	Valley Type: VI	

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	7.00 (A)	Bankfull Height (ft) =	0.97 (B)	(A) / (B) =	7.22 (C)	10.0
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Root Depth / Study Bank Height (E)

Root Depth (ft) =	2.00 (D)	Study Bank Height (ft) =	7.00 (A)	(D) / (A) =	0.29 (E)	5.9
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Weighted Root Density (G)

Root Density as % =	10.00 (F)	(F) × (E) =	2.86 (G)	9.5
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Bank Angle (H)

Bank Angle as Degrees =	90 (H)	8.0
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Surface Protection (I)

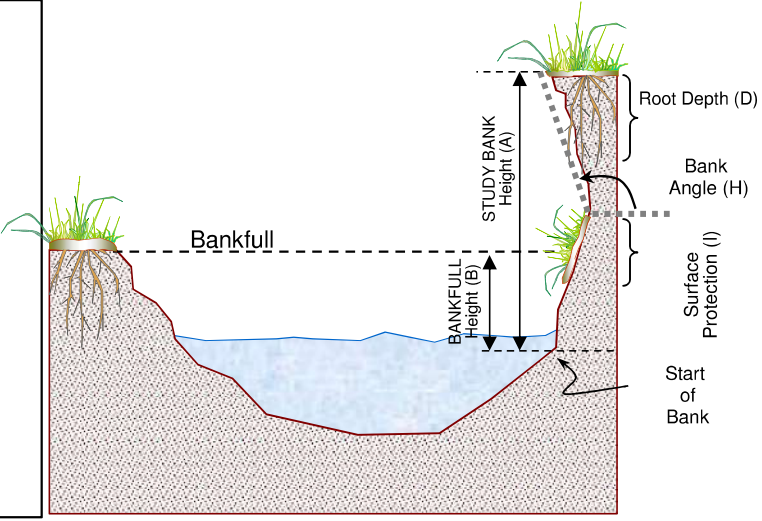
Surface Protection as % =	5% (I)	10.0
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Bank Material Adjustment:

Bedrock (Overall Very Low BEHI) Boulders (Overall Low BEHI) Cobble (Subtract 10 points if uniform medium to large cobble) Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand) Sand (Add 10 points) Silt/Clay (no adjustment)	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">Bank Material Adjustment</div> <div style="border: 1px solid black; padding: 5px;">Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage</div>
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Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Very High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		43.4





Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)									
Stream: Timber Branch					Location: BEHI #4				
Station: 48 ft			Stream Type: G3			Valley Type: VI			
Observers: Biggs/Hepp					Date: 3/28/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1)	Channel pattern, transverse bar or split channel/central bar creating NBS					Level I	Reconnaissance		
(2)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})					Level II	General prediction		
(3)	Ratio of pool slope to average water surface slope (S_p / S)					Level II	General prediction		
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})					Level II	General prediction		
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})					Level III	Detailed prediction		
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})					Level III	Detailed prediction		
(7)	Velocity profiles / Isovels / Velocity gradient					Level IV	Validation		
Level I	(1)	Transverse and/or central bars-short and/or discontinuous.....NBS = High / Very High Extensive deposition (continuous, cross-channel).....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.....NBS = Extreme							
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	Ratio R_c / W_{bkf}	Near-Bank Stress (NBS)	<div style="border: 1px solid black; padding: 10px; text-align: center;"> Dominant Near-Bank Stress High / Very High </div>			
	(3)	Pool Slope S_p	Average Slope S	Ratio S_p / S	Near-Bank Stress (NBS)				
	(4)	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p / S_{rif}	Near-Bank Stress (NBS)				
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	Ratio d_{nb} / d_{bkf}	Near-Bank Stress (NBS)				
	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft ²)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft ²)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
Level IV	(7)	Velocity Gradient (ft / sec / ft)		Near-Bank Stress (NBS)					
Converting Values to a Near-Bank Stress (NBS) Rating									
Near-Bank Stress (NBS) ratings	Method number								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50		
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00		
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60		
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00		
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40		
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
Overall Near-Bank Stress (NBS) rating						High			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Timber Branch		Location: BEHI #6	
Station: 160 Ft		Observers: Biggs/Hepp	
Date: 3/28/18	Stream Type: G3	Valley Type: V1	

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	10.00 (A)	Bankfull Height (ft) =	0.97 (B)	(A) / (B) =	10.31 (C)
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Root Depth / Study Bank Height (E)

Root Depth (ft) =	1.00 (D)	Study Bank Height (ft) =	10.00 (A)	(D) / (A) =	0.10 (E)
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Weighted Root Density (G)

Root Density as % =	10.00 (F)	(F) × (E) =	1.00 (G)
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Bank Angle (H)

Bank Angle as Degrees =	90 (H)
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Surface Protection (I)

Surface Protection as % =	15% (I)
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BEHI Score (Fig. 3-7)

10.0

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI) Boulders (Overall Low BEHI) Cobble (Subtract 10 points if uniform medium to large cobble) Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand) Sand (Add 10 points) Silt/Clay (no adjustment)
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Bank Material Adjustment

5

Stratification Adjustment

5

Very Low	Low	Moderate	High	Very High	Extreme	
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

Adjective Rating and Total Score

Extreme
54.0

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)									
Stream: Timber Branch					Location: BEHI #6				
Station: 160 ft			Stream Type: G3			Valley Type: V1			
Observers: Biggs/Hepp					Date: 3/28/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1)	Channel pattern, transverse bar or split channel/central bar creating NBS					Level I	Reconnaissance		
(2)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})					Level II	General prediction		
(3)	Ratio of pool slope to average water surface slope (S_p / S)					Level II	General prediction		
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})					Level II	General prediction		
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})					Level III	Detailed prediction		
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})					Level III	Detailed prediction		
(7)	Velocity profiles / Isovels / Velocity gradient					Level IV	Validation		
Level I	(1)	Transverse and/or central bars-short and/or discontinuous.....NBS = High / Very High Extensive deposition (continuous, cross-channel).....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.....NBS = Extreme							
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	Ratio R_c / W_{bkf}	Near-Bank Stress (NBS)	<div style="border: 1px solid black; padding: 5px; text-align: center;"> Dominant Near-Bank Stress High / Very High </div>			
	(3)	Pool Slope S_p	Average Slope S	Ratio S_p / S	Near-Bank Stress (NBS)				
(4)	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p / S_{rif}	Near-Bank Stress (NBS)					
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	Ratio d_{nb} / d_{bkf}	Near-Bank Stress (NBS)				
	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft ²)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft ²)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
Level IV	(7)	Velocity Gradient (ft / sec / ft)		Near-Bank Stress (NBS)					
Converting Values to a Near-Bank Stress (NBS) Rating									
Near-Bank Stress (NBS) ratings	Method number								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50		
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00		
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60		
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00		
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40		
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
Overall Near-Bank Stress (NBS) rating						High			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Timber Branch		Location: BEHI #7	
Station: 42 Ft		Observers: Biggs/Hepp	
Date: 3/28/18	Stream Type: G3	Valley Type: VI	

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	6.00	(A)	Bankfull Height (ft) =	0.97	(B)	(A) / (B) =	6.19	(C)
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Root Depth / Study Bank Height (E)

Root Depth (ft) =	1.50	(D)	Study Bank Height (ft) =	6.00	(A)	(D) / (A) =	0.25	(E)
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Weighted Root Density (G)

Root Density as % =	10.00	(F)	(F) × (E) =	2.50	(G)
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Bank Angle (H)

Bank Angle as Degrees =	90	(H)
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Surface Protection (I)

Surface Protection as % =	10%	(I)
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BEHI Score (Fig. 3-7)

10.0

Bank Material Adjustment:

- Bedrock** (Overall Very Low BEHI)
- Boulders** (Overall Low BEHI)
- Cobble** (Subtract 10 points if uniform medium to large cobble)
- Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- Sand** (Add 10 points)
- Silt/Clay** (no adjustment)

Bank Material Adjustment

5

Stratification Adjustment


Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

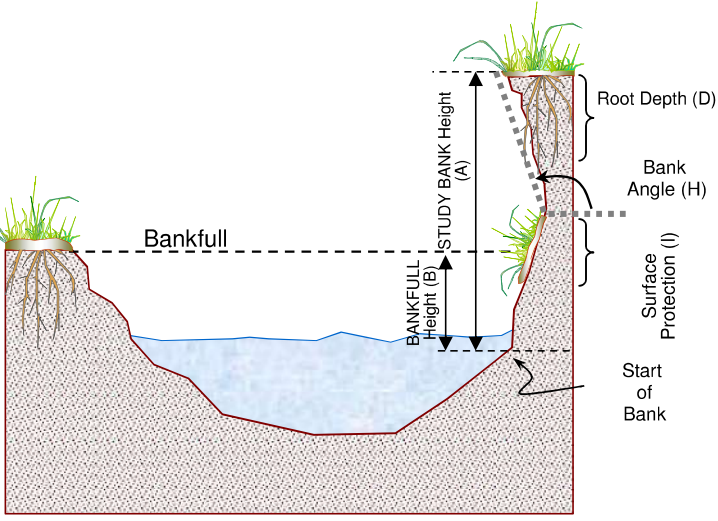
5

Very Low	Low	Moderate	High	Very High	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and Total Score

Extreme
53.2





Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)									
Stream: Timber Branch					Location: BEHI #7				
Station: 42 ft			Stream Type: G3			Valley Type: VI			
Observers: Biggs/Hepp					Date: 3/28/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1)	Channel pattern, transverse bar or split channel/central bar creating NBS					Level I	Reconnaissance		
(2)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})					Level II	General prediction		
(3)	Ratio of pool slope to average water surface slope (S_p / S)					Level II	General prediction		
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})					Level II	General prediction		
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})					Level III	Detailed prediction		
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})					Level III	Detailed prediction		
(7)	Velocity profiles / Isovels / Velocity gradient					Level IV	Validation		
Level I	(1)	Transverse and/or central bars-short and/or discontinuous.....NBS = High / Very High Extensive deposition (continuous, cross-channel).....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.....NBS = Extreme							
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	Ratio R_c / W_{bkf}	Near-Bank Stress (NBS)	<div style="border: 1px solid black; padding: 10px; text-align: center;"> Dominant Near-Bank Stress High / Very High </div>			
	(3)	Pool Slope S_p	Average Slope S	Ratio S_p / S	Near-Bank Stress (NBS)				
	(4)	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p / S_{rif}	Near-Bank Stress (NBS)				
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	Ratio d_{nb} / d_{bkf}	Near-Bank Stress (NBS)				
	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft ²)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft ²)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
Level IV	(7)	Velocity Gradient (ft / sec / ft)		Near-Bank Stress (NBS)					
Converting Values to a Near-Bank Stress (NBS) Rating									
Near-Bank Stress (NBS) ratings	Method number								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50		
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00		
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60		
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00		
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40		
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
Overall Near-Bank Stress (NBS) rating						Very High			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Timber Branch		Location: BEHI #9	
Station: 140 Ft		Observers: Biggs/Hepp	
Date: 3/28/18	Stream Type: G3	Valley Type: VI	

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	9.00 (A)	Bankfull Height (ft) =	0.97 (B)	(A) / (B) =	9.28 (C)
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Root Depth / Study Bank Height (E)

Root Depth (ft) =	5.00 (D)	Study Bank Height (ft) =	9.00 (A)	(D) / (A) =	0.56 (E)
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Weighted Root Density (G)

Root Density as % =	30.00 (F)	(F) × (E) =	16.67 (G)
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Bank Angle (H)

Bank Angle as Degrees =	80 (H)
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Surface Protection (I)

Surface Protection as % =	5% (I)
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BEHI Score (Fig. 3-7)

10.0

Bank Material Adjustment:

- Bedrock** (Overall Very Low BEHI)
- Boulders** (Overall Low BEHI)
- Cobble** (Subtract 10 points if uniform medium to large cobble)
- Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- Sand** (Add 10 points)
- Silt/Clay** (no adjustment)

Bank Material Adjustment

5


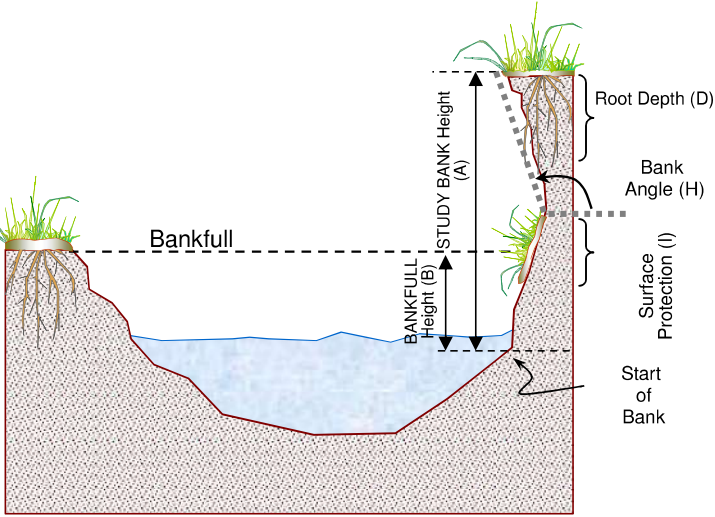
Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

5

Very Low	Low	Moderate	High	Very High	Extreme	
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

Adjective Rating and Total Score	Extreme
46.8	

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)									
Stream: Timber Branch					Location: BEHI #9				
Station: 140 ft			Stream Type: G3			Valley Type: VI			
Observers: Biggs/Hepp					Date: 3/28/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1)	Channel pattern, transverse bar or split channel/central bar creating NBS					Level I	Reconnaissance		
(2)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})					Level II	General prediction		
(3)	Ratio of pool slope to average water surface slope (S_p / S)					Level II	General prediction		
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})					Level II	General prediction		
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})					Level III	Detailed prediction		
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})					Level III	Detailed prediction		
(7)	Velocity profiles / Isovels / Velocity gradient					Level IV	Validation		
Level I	(1)	Transverse and/or central bars-short and/or discontinuous.....NBS = High / Very High Extensive deposition (continuous, cross-channel).....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.....NBS = Extreme							
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	Ratio R_c / W_{bkf}	Near-Bank Stress (NBS)	<div style="border: 1px solid black; padding: 10px; text-align: center;"> Dominant Near-Bank Stress High </div>			
	(3)	Pool Slope S_p	Average Slope S	Ratio S_p / S	Near-Bank Stress (NBS)				
(4)	Pool Slope S_p	Riffle Slope S_{rif}	Ratio S_p / S_{rif}	Near-Bank Stress (NBS)					
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	Ratio d_{nb} / d_{bkf}	Near-Bank Stress (NBS)				
	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft ²)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft ²)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)
Level IV	(7)	Velocity Gradient (ft / sec / ft)		Near-Bank Stress (NBS)					
<div style="border: 1px solid black; padding: 5px;"> Converting Values to a Near-Bank Stress (NBS) Rating </div>									
Near-Bank Stress (NBS) ratings		Method number							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Very Low		N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50	
Low		N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00	
Moderate		N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60	
High		See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00	
Very High		(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40	
Extreme		Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40	
Overall Near-Bank Stress (NBS) rating							High		

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream: Timber Branch		Location: Project Reach					
Graph Used: District of Columbia		Total Stream Length (ft): 737				Date: 7/17/2018	
Observers: Biggs/Hepp		Valley Type: VI				Stream Type: G3	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	NBS rating (Worksheet 3-12) (adjective)	Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft³/yr)	Erosion Rate (tons/yr/ft)
1. BEHI #1	Extreme	Very High	3.20	32.0	6.0	614.40	1.056
2. BEHI #2*	High	Very High	1.70	19.0	7.0	226.10	0.655
3. BEHI #3	Extreme	High	2.40	166.0	8.0	3187.20	1.056
4. BEHI #4	Very High	High	1.00	48.0	7.0	336.00	0.385
5. BEHI #5*	Very High	Low	0.40	32.0	3.5	44.80	0.077
6. BEHI #6	Extreme	High	2.40	160.0	10.0	3840.00	1.320
7. BEHI #7	Extreme	Very High	3.20	42.0	6.0	806.40	1.056
8. BEHI #8*	Moderate	Low	0.12	98.0	3.5	41.16	0.023
9. BEHI #9	Extreme	High	2.40	140.0	9.0	3024.00	1.188
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total Erosion (ft ³ /yr)	12120.06	
Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27}					Total Erosion (yds ³ /yr)	448.89	
Dry Bulk Density of the Soil is 110 lb/cf.					Total Erosion (tons/yr)	666.60	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					Total Erosion (tons/yr/ft)	0.904	

* BEHI and NBS ratings were determined using ocular estimates and field calibration technique as described in Section 3.2